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NUMERICAL SIMULATION OF CHARGE COUPLED DEVICE  
OPERATION, ABBREVIATED FORM

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California Institute of Technology

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Numerical Simulation of Charge Coupled Device Operation

Abbreviated Form

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The research carried out under this contract consisted of a detailed theoretical study of the operation of both surface and buried channel charge coupled devices (CCD). In the case of surface charge coupled devices, the primary results were: the development of the technologically important push clock clocking scheme, the numerical simulation of the operation of two and four phase overlapping gate CCD, the estimation of the importance of interface states in limiting the charge transfer for a number of different clocking schemes, the estimation of the small signal or long time decay of the charge in surface channel CCD.

In the case of buried channel CCD (BCCD), the primary results were: the development of detailed one and two dimensional solutions for the electrostatics of overlapping gate BCCCD, and the numerical simulation of the details of the operation of BCCCD.

Finally, a new CCD device structure was explored, the Schottky barrier CCD. This new device structure may have potential application in the manufacture of CCD in materials other than silicon.

### Publications

1. A. M. Mohsen, T. C. McGill, M. Anthony, and C. A. Mead, Applied Physics Letters 22, 192-175 (1973).
2. A. M. Mohsen, T. C. McGill, Y. Daimon, and C. A. Mead, Journal of Solid State Circuits SC-8, 125 (1973).
3. A. M. Mohsen, T. C. McGill, and C. A. Mead, Journal of Solid State Circuits SC-8, 191 (1973).
4. A. M. Mohsen, T. C. McGill and C. A. Mead, ISSCC Digest of Technical Papers 15, 248 (1972).
5. Y. Daimon, A. Mohsen, and T. C. McGill, IEEE Transactions on Electron Devices ED-21, 26f (1974).
6. Y. Daimon, A. M. Mohsen, and T. C. McGill, ISSCC Digest of Technical Papers 17, 146 (1974).
7. Y. Daimon and T. McGill, "Electrostatic Analysis of Buried Channel Charge Coupled Devices Part I: One Dimensional Structure", in preparation.
8. Y. Daimon and T. C. McGill, "Electrostatic Analysis of Buried Channel Charge Coupled Device Part II: Two Dimensional Analysis", in preparation.
9. Y. Daimon and T. C. McGill, "Free Charge Transfer in Buried Channel Charge Coupled Devices", in preparation.
10. Y. Daimon and T. C. McGill, "Electrostatic Analysis of GaAs buried Channel Charge Coupled Devices with Schottky Barriers", in preparation.
11. A. M. Mohsen, R. Bower, T. C. McGill, and T. Zimmerman, "Overlapping-Gate Buried Channel Charge Coupled Devices", Electronics Letters 9, 396 (1973).
12. T. C. McGill, M. A. Nicolet, and K. K. Thornber, "Equivalence of the Langevin Method and the Impedance-Field Method of Calculating Noise in Devices", Solid State Electronics 17, 107 (1974).

### Theses

1. A. M. Mohsen, "Incomplete Charge Transfer in Overlapping Gate Charge Coupled Devices", Ph.D. Thesis, California Institute of Technology, March 1973.
2. Yoshiaki Daimon-Hagihara, "Charge Transfer in Charge Coupled Devices", Ph.D. Thesis, California Institute of Technology, February 1975.

### Major Talks

1. A. M. Mohsen, T. C. McGill, and C. A. Mead, ISSCC Digest of Technical Papers 15, 248 (1972).
2. A. M. Mohsen, Device Research Conference (Edmonton, Canada, June, 1972).
3. A. M. Mohsen, Gordon Research Conference (New Hampshire, August 1972).
4. Y. Daimon, A. M. Mohser, and T. C. McGill, ISSCC Digest of Technical Papers 17, 146 (1974).

### Movies

1. Simulation of Charge Transfer in Surface Channel Charge Coupled Devices.
2. Simulation Charge Transfer in Buried Channel Charge Coupled Devices.